The Future of Energy for Transportation: Why a Transition?

David L. Greene

Corporate Fellow
Oak Ridge National Laboratory

Senior Fellow
Howard H. Baker, Jr. Center for Public Policy
The University of Tennessee

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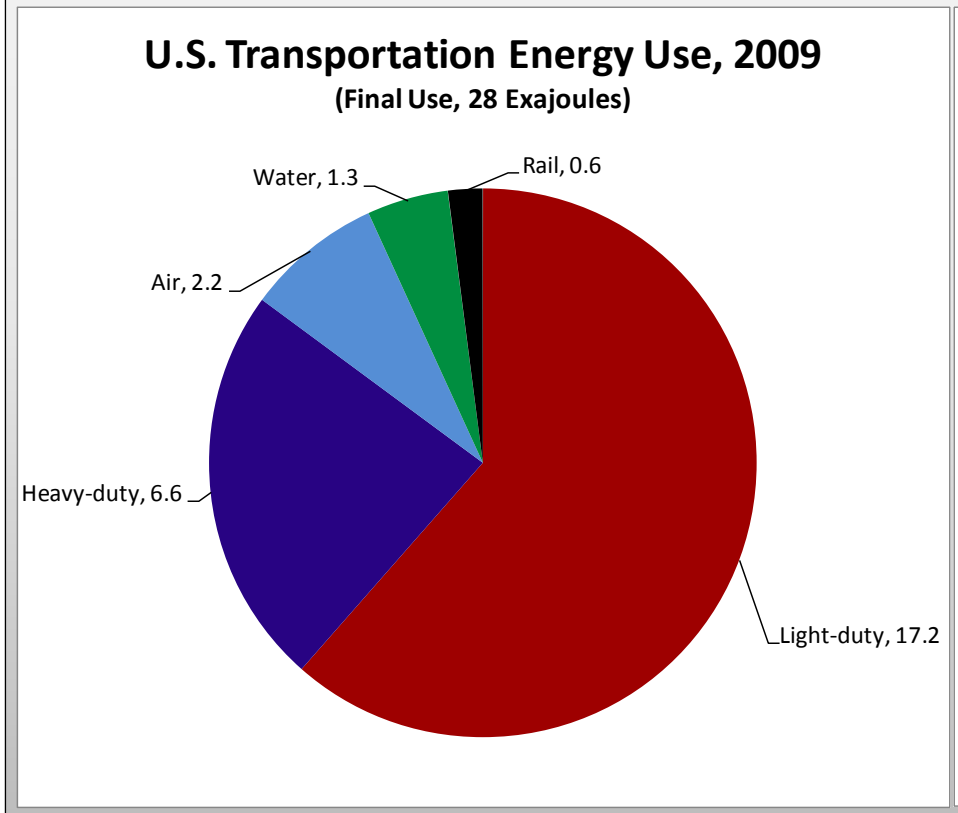
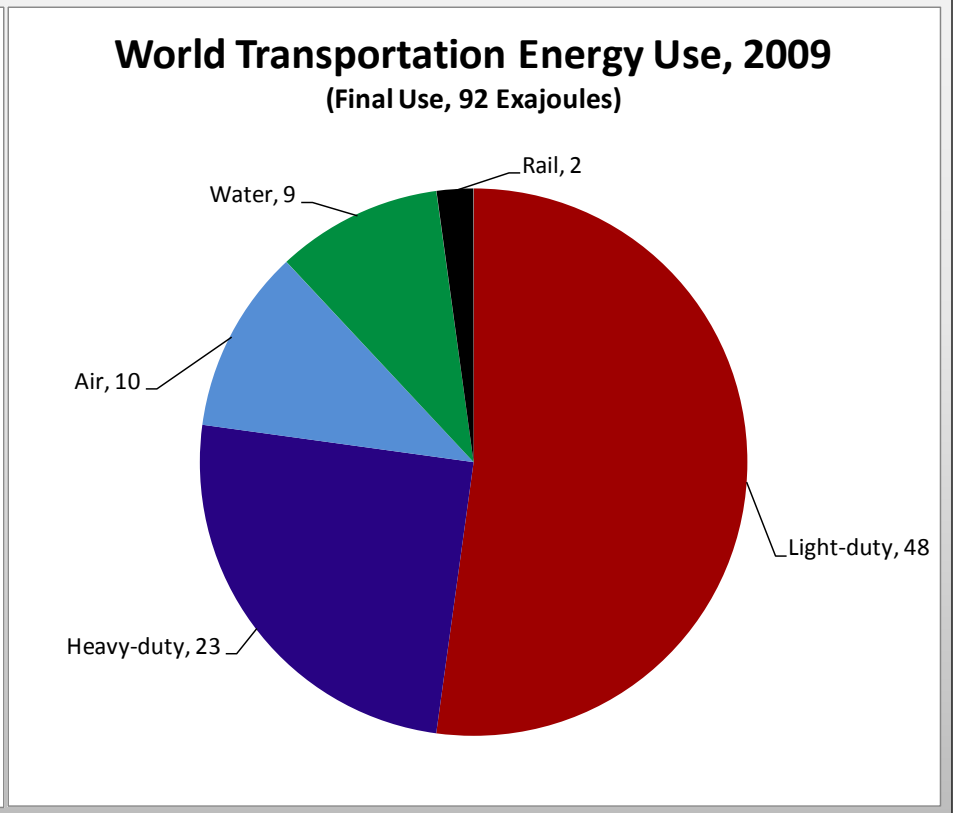
The world, the U.S. and transportation are at an energy crossroads.

- Transportation is work; work requires energy.
- Why change?
- Is there a sustainable energy future for transportation?
  - 95% dependent on petroleum, 20% of global CO_2
  - Transition to unconventional petroleum or…?
- The importance of energy efficiency.
  - CAFE and GHG emissions standards
  - The transition: how are we going to do that?

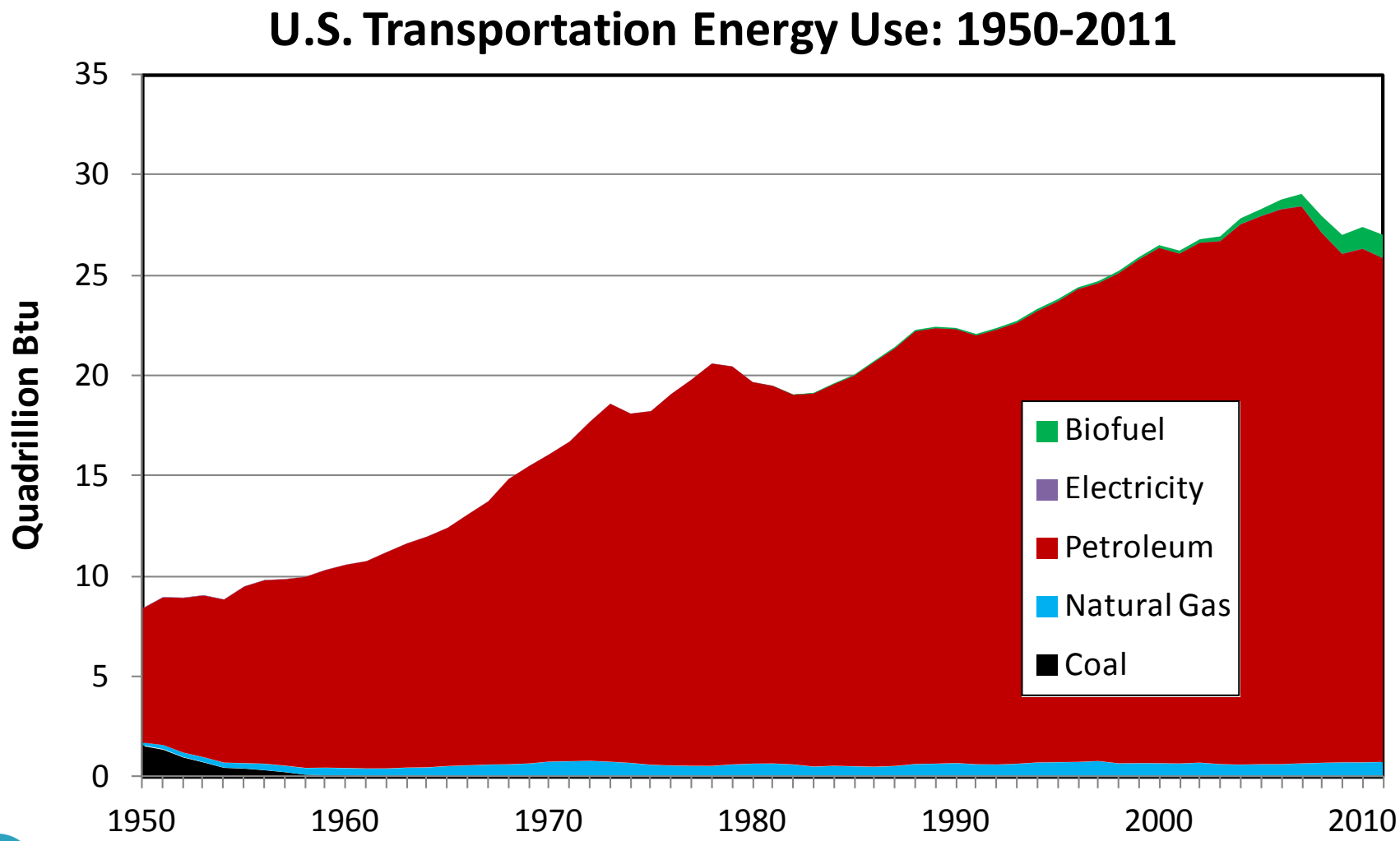
World/U.S. transport energy use is 95% dependent on petroleum and 80%/85% for road transport.





Sources: Davis et al., *Transportation Energy Data Book* Ed. 31, table 2.6; International Energy Agency, *Energy Technology Perspectives 2010*, p. 273.

Transportation: still petroleum dependent.

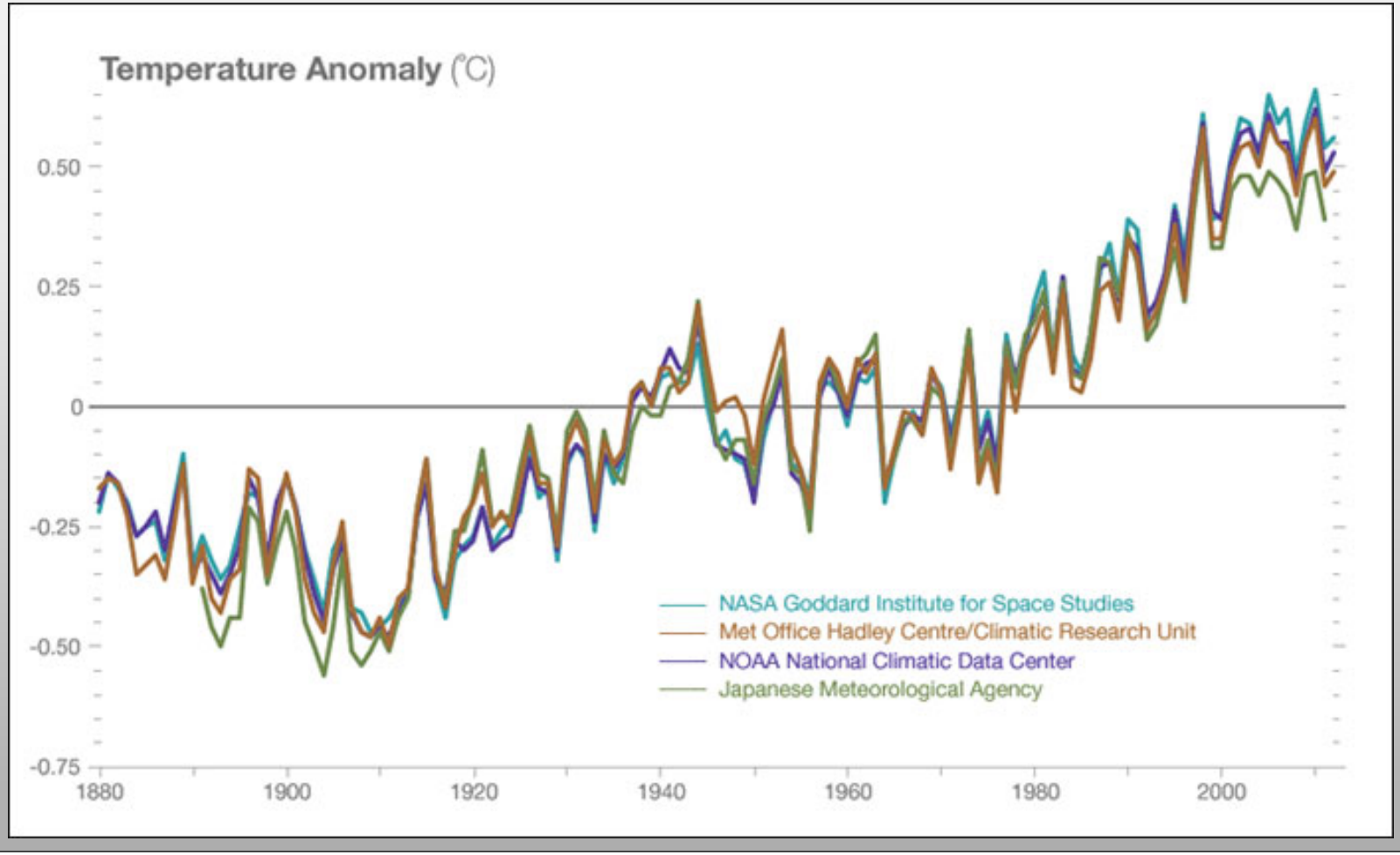


Energy Information Administration, Annual Energy Review 2011, table 2.1e.

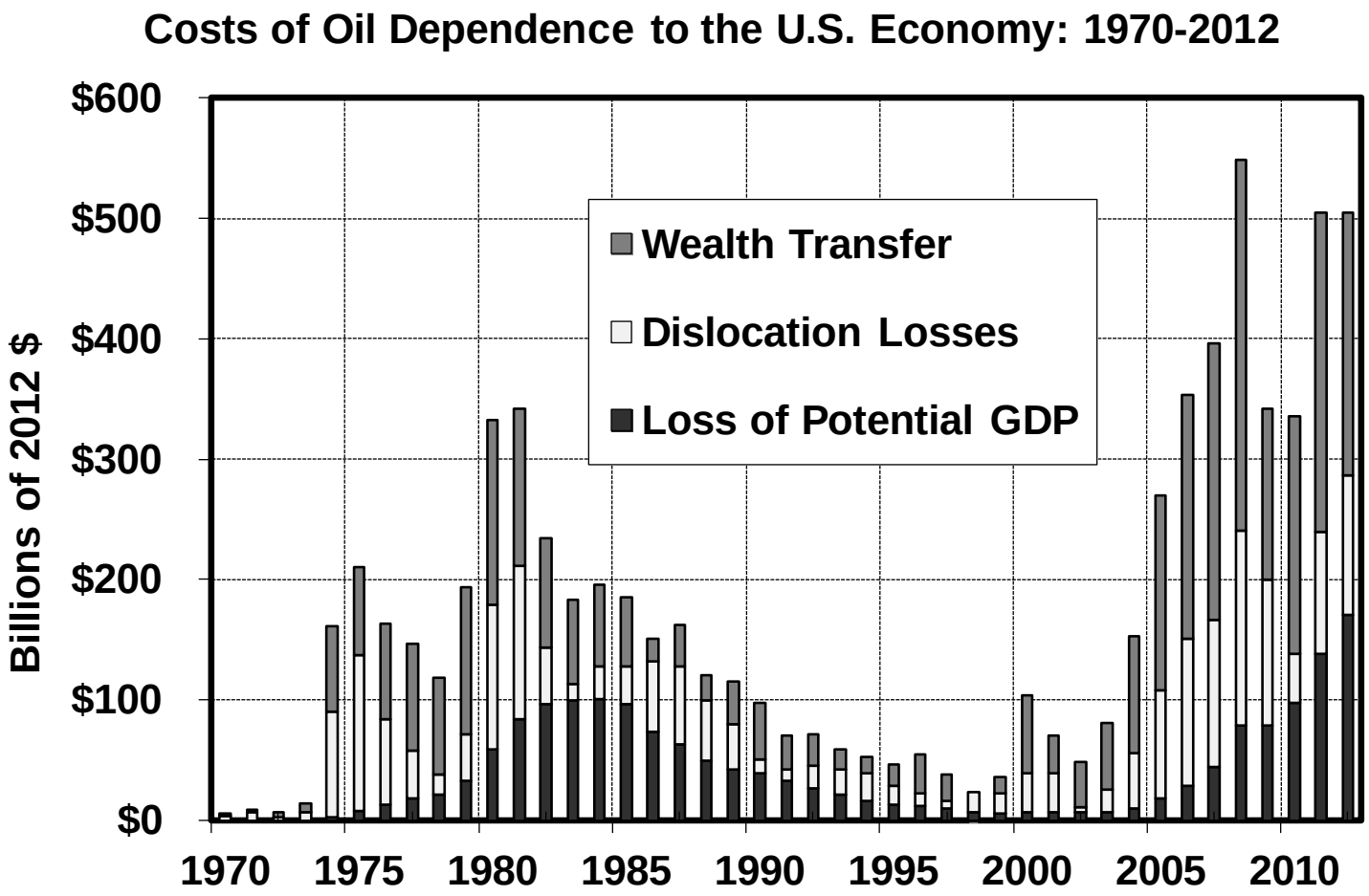
Yes, the climate is warming.
Yes, it is causing more extreme weather events.

Consensus: 97% of climate scientists agree

Temperature data from four international science institutions. All show rapid warming in the past few decades and that the last decade has been the warmest on record. http://climate.nasa.gov/scientific-consensus



The estimated direct economic costs of U.S. oil dependence for 2011-12 are $1 trillion.



Energy security problem solved?

35% increase in US technically recoverable resources.

(EIA, 2013. *Technically Recoverable Shale Oil and Shale Gas Resources*, June.
http://www.eia.gov/analysis/studies/worldshalegas/pdf/fullreport.pdf?zscb=56333520

Patti Domm, CNBC.com – 2 days

US is on fast-track to energy independence, report suggests

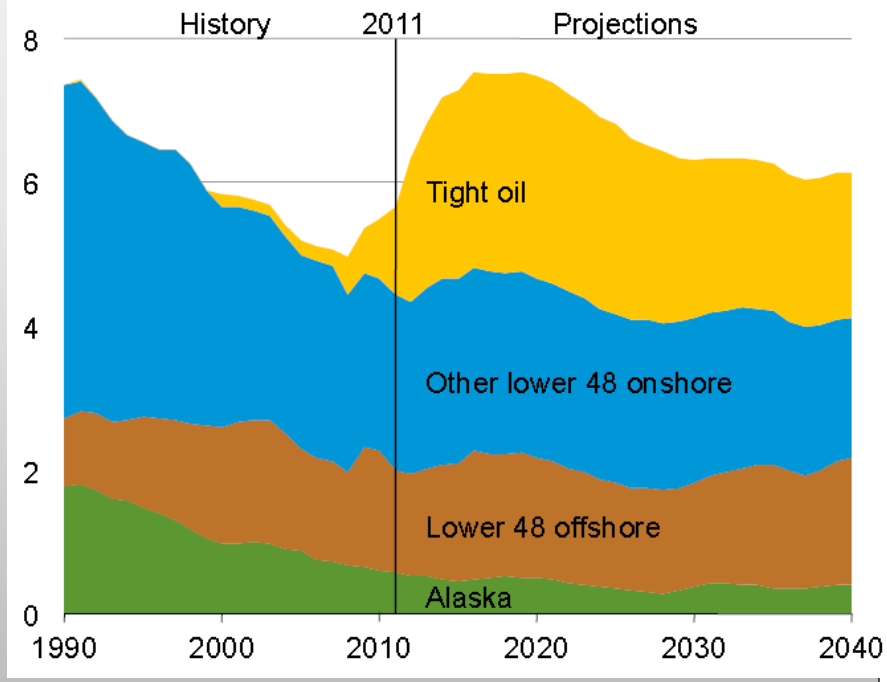
U.S. oil and gas production is evolving so rapidly — and demand is dropping so quickly — that in just five years the U.S. could no longer need to buy oil from any source but Canada, according to Citigroup's global head of commodities research.

OPEC Survival Uncertain Amid U.S. Oil Output Growth

By Asjylyn Loder - Feb 13, 2013 10:20 AM ET

"OPEC should find it challenging to survive another 60 years, let alone another decade," analysts led by Ed Morse, global head of commodities research at Citigroup in New York, said in a report released today.

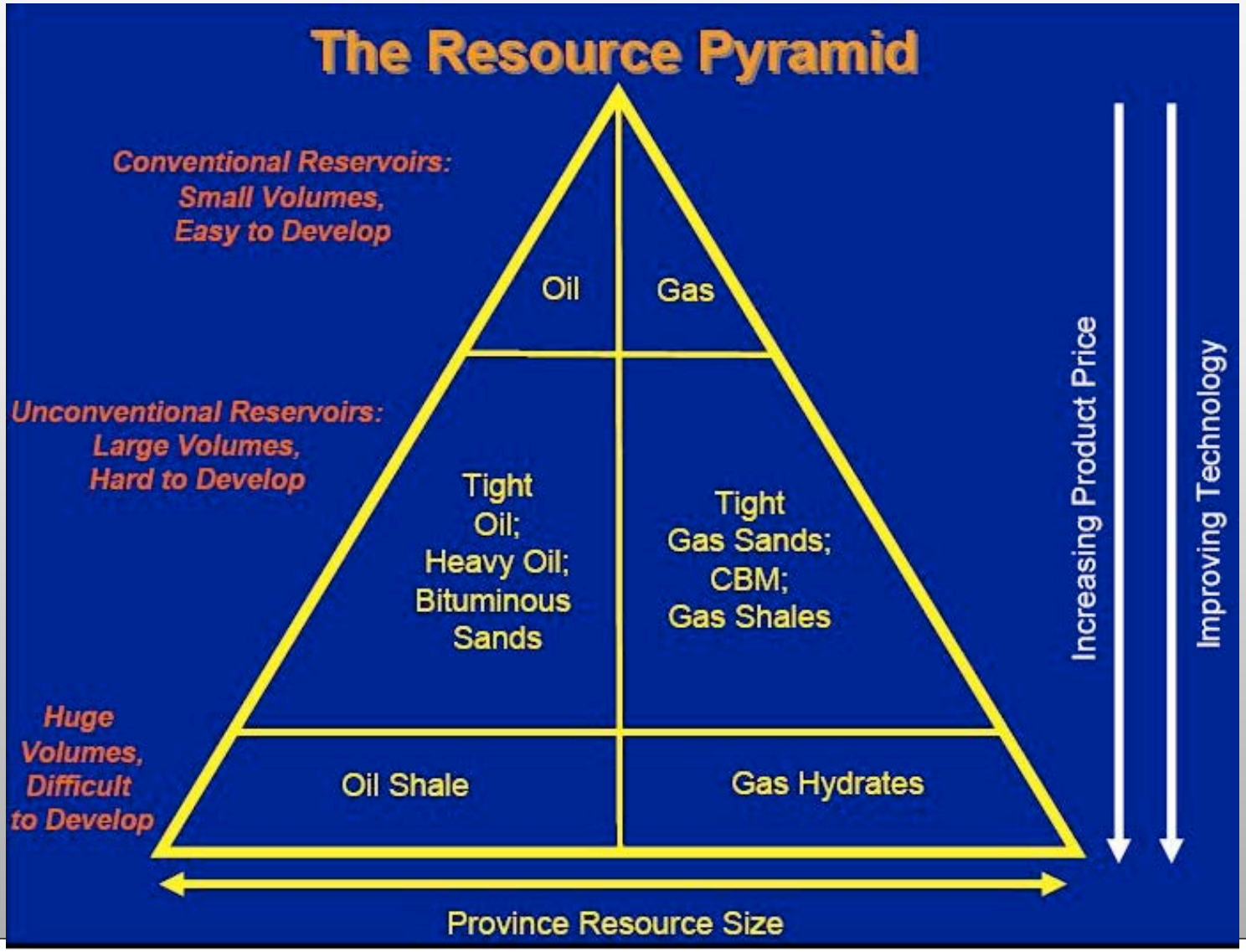
Figure 1. U.S. domestic crude oil production by source, 1990-2040 (million barrels per day)



EIA, Annual Energy Outlook 2013.

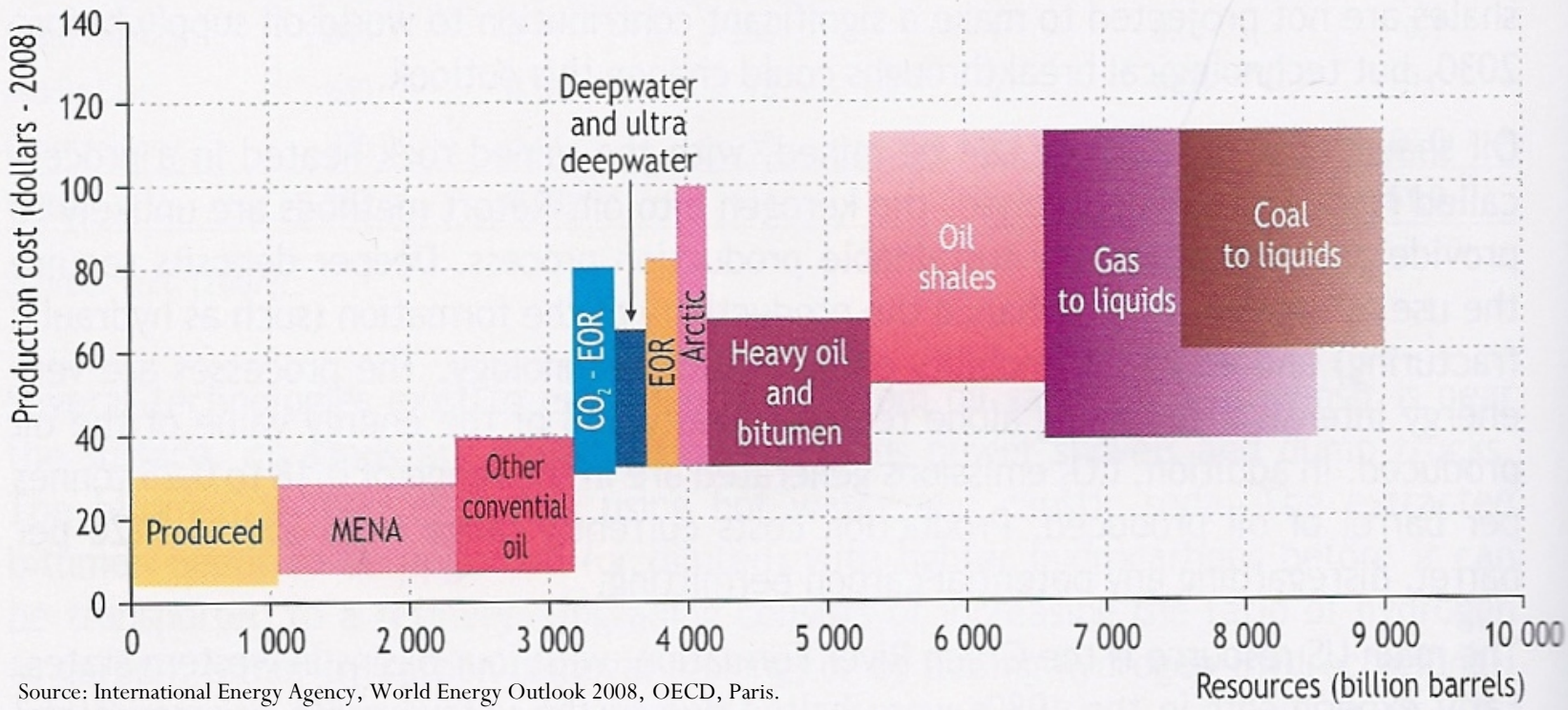
Shale gas & oil: an unexpected revolution in global energy resources or the market at work?

In 2012: 29% of US crude oil and 40% of US natural gas production.



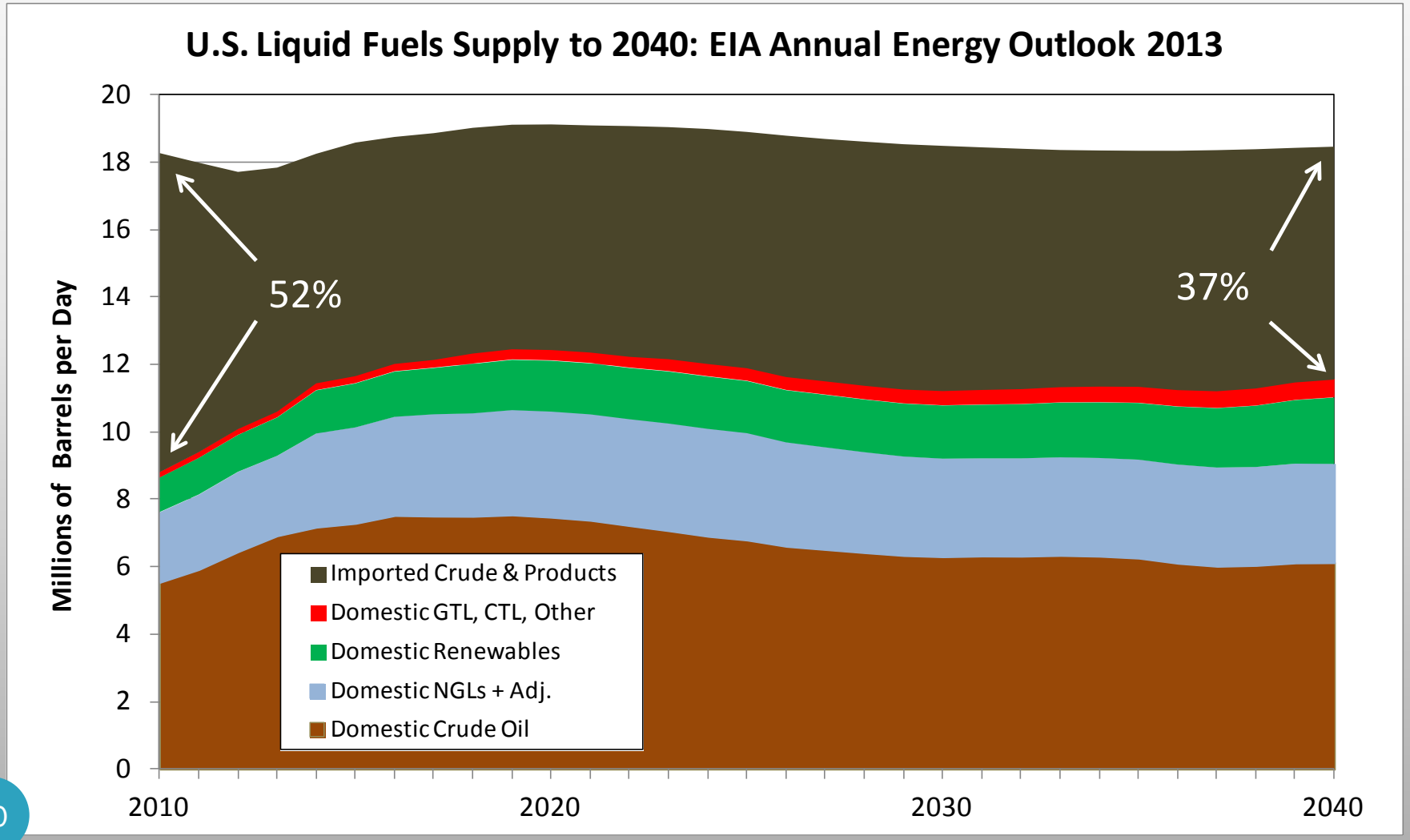
The International Energy Agency estimates that roughly an order of magnitude more liquid fossil fuel can be produced at prices the world has already proven it is willing to pay.

Figure 9.10 • Long-term oil-supply cost curve



Source: International Energy Agency, World Energy Outlook 2008, OECD, Paris.

Energy independence? In 2010 expenditures on imported oil at $81/bbl were 2.1% of GDP. In 2040 at $160/bbl import expenditures are projected to be 1.5% of GDP.



The Global Energy Assessment: global energy sustainability requires a transition from petroleum.

- "Without question a radical transformation of the present energy system will be required over the coming decades."
- "An effective transformation requires immediate action."
- "In all *(sustainable, ed.)* pathways conventional oil is essentially phased out shortly after 2050. Every scenario that achieves the sustainability goals essentially eliminates petroleum use."

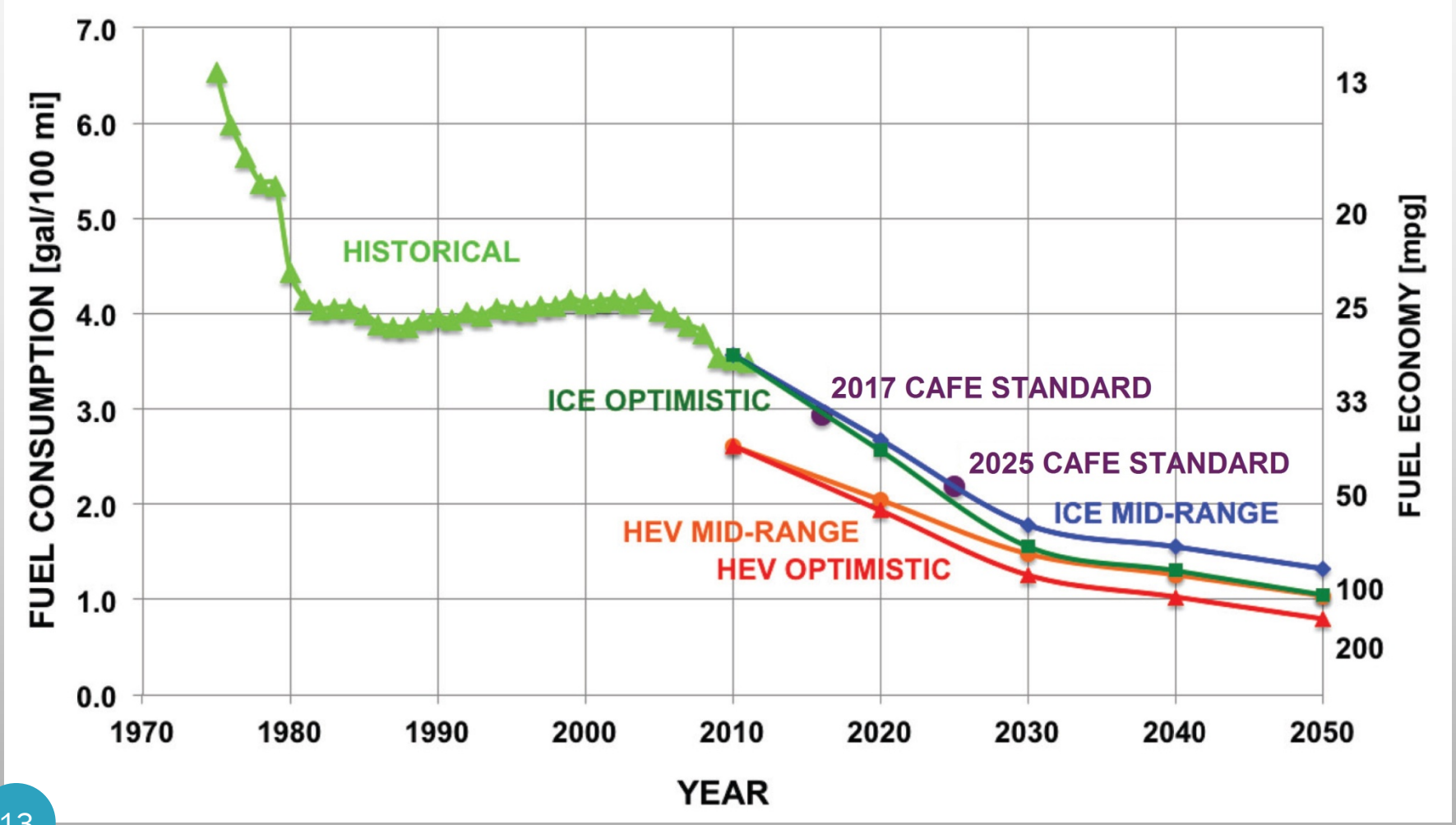
- GEA, 2012: *Global Energy Assessment - Toward a Sustainable Future*, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria.

#1 Strategy: Increase Energy Efficiency.
Goal: 50% reduction in GHG from 2009.
Doubling energy efficiency reduces the need for low-carbon energy by a factor of three.

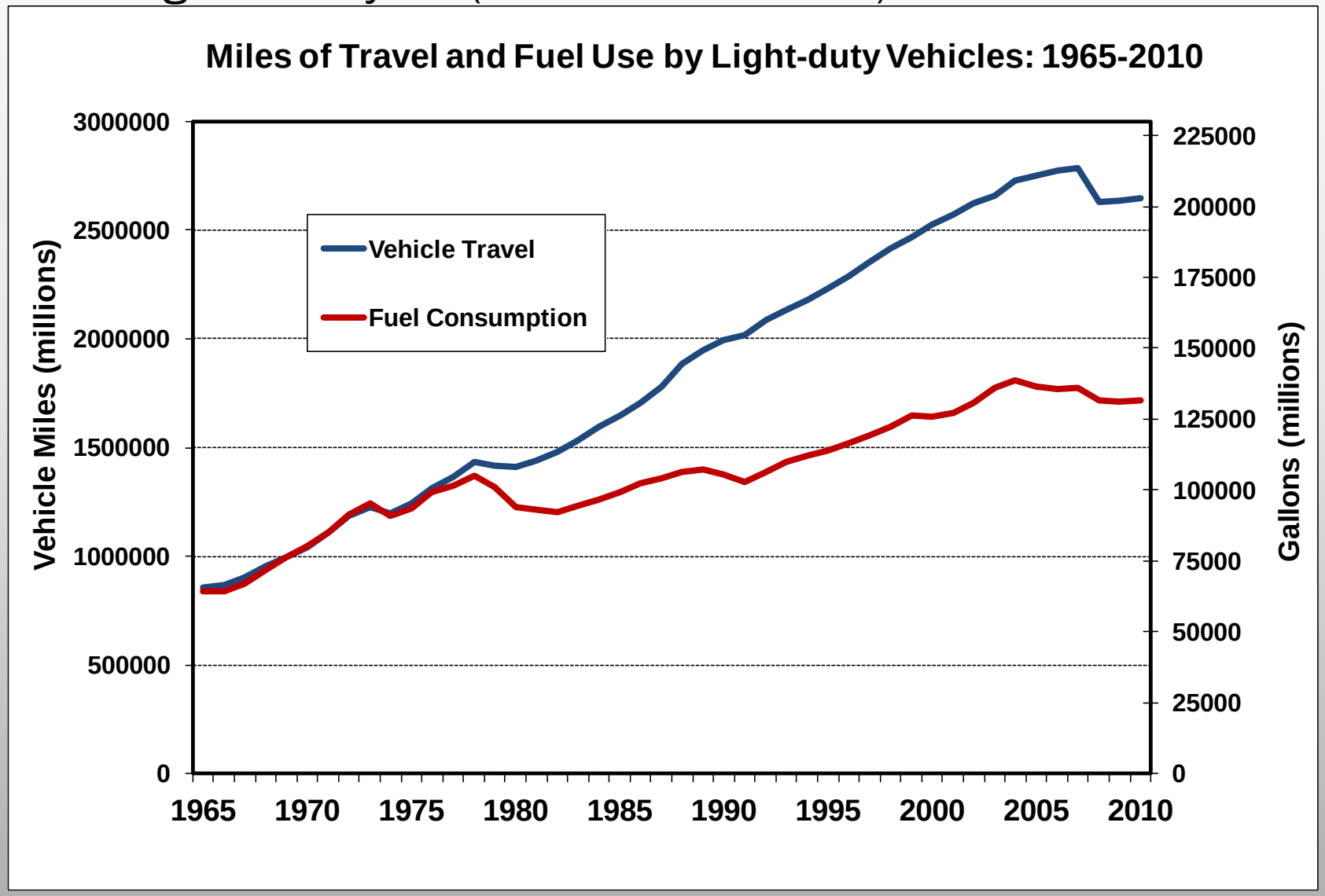
Mode	World Transport Energy Use (EJ) 2009	Growth Rate (%)	Energy Use 2050	Energy Intensity (%)	Energy Use with Rebound 2050	Energy Use with Rebound 2050
Light-duty	48	1.3%	81.5	-50%	40.8	43.7
Heavy-duty	23	1.5%	42.3	-50%	21.2	22.7
Air	10	2.0%	22.5	-50%	11.3	12.1
Water	9	1.8%	18.7	-33%	2.0	2.1
Rail	2	1.0%	3.0	-33%	2.0	2.1
TOTAL	92		168		88	94

Very likely, vehicle energy efficiency can be more than doubled by 2050.

(NRC, *Transitions to Alternative Vehicles and Fuels*, 2013)

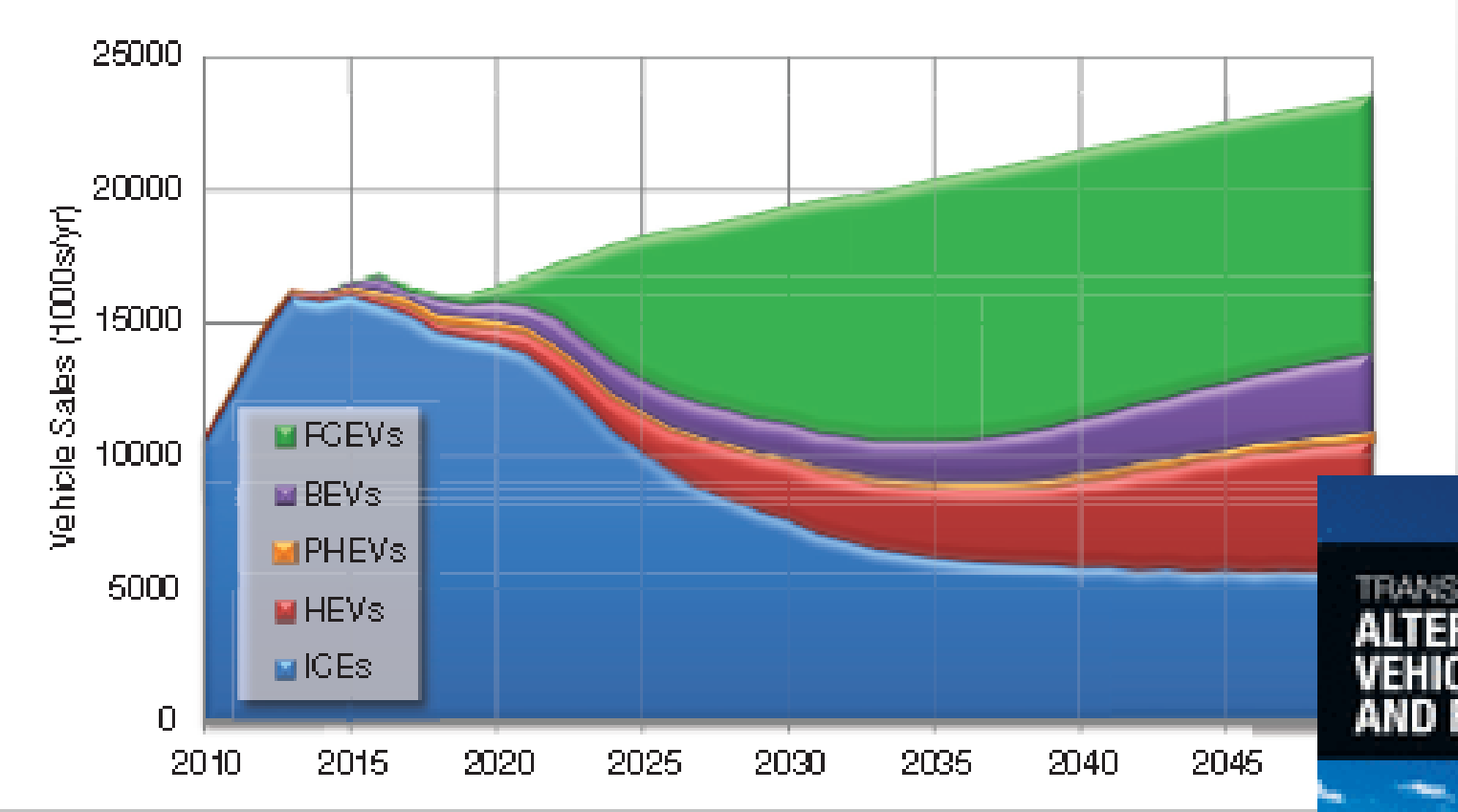


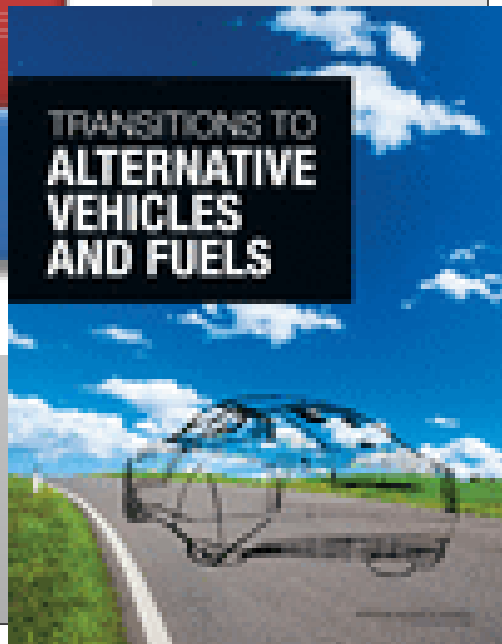
Efficiency works. MPG improvements since the 1970's decoupled VMT and fuel use, saving consumers about 70 billion gallons a year (about $250 billion).



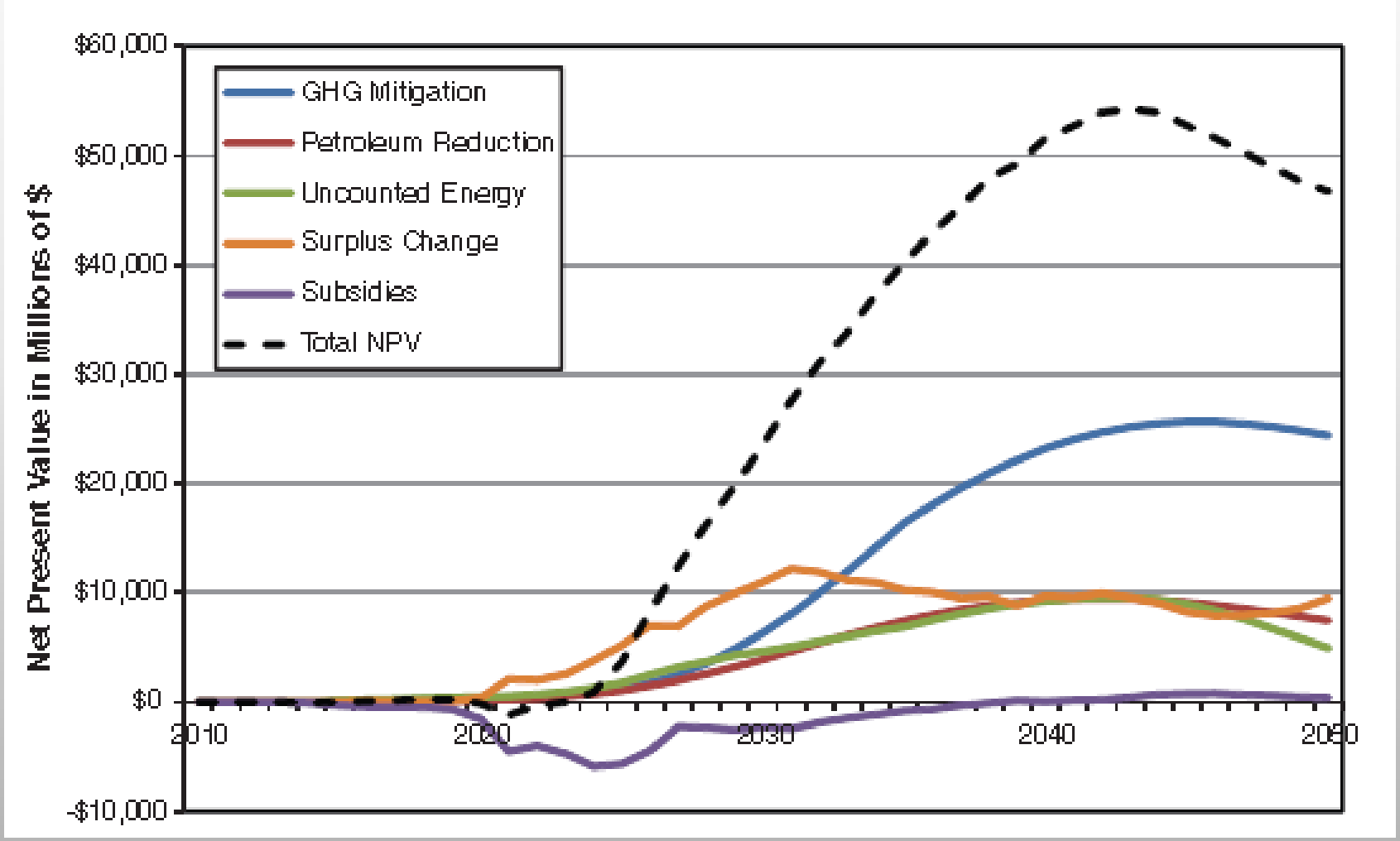
Davis et al., 2013. *Transportation Energy Data Book, Ed. 31*, Oak Ridge National Laboratory.

#2 Strategy: Electro-mobility. NRC: Promoting both FCVs and PEVs led to an 88% reduction in GHG emissions and a 100% reduction in petroleum use by 2050.



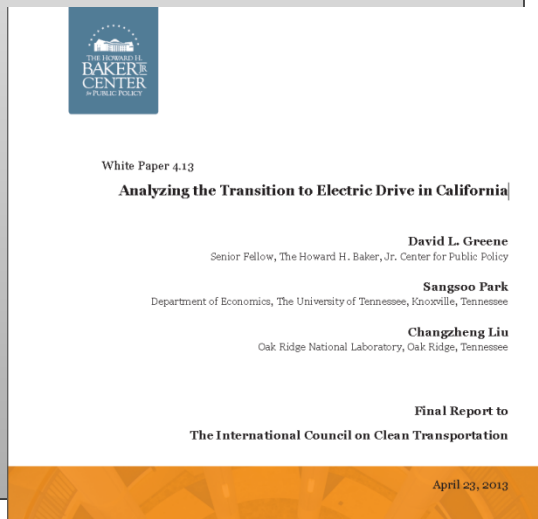


The transition required subsidies for a decade or so. Total benefits appeared to exceed costs by roughly an order of magnitude. But…



Why is an energy transition for the public good a different kind of problem?

- It takes decades. The difference between social and private discount rates becomes critical.
- It requires technological progress which is inherently uncertain.
- Externalities are involved but not all the social costs are externalities (e.g., monopoly power in world oil market).
- There are other important market shortcomings (e.g., the "energy paradox").
- The transition creates external benefits which are difficult for private agents to capture. These create "tipping points".
  - Value of fuel availability to car buyers
  - Learning-by-doing spillover
  - Reduction of risk-aversion of majority
  - Value of choice diversity (versus scale economies)
- "Deep Uncertainty"


White Paper 4.13

Analyzing the Transition to Electric Drive in California

David L. Greene
Senior Fellow, The Howard H. Baker, Jr. Center for Public Policy

Sangsoo Park
Department of Economics, The University of Tennessee, Knoxville, Tennessee

Changzheng Liu
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Final Report to
The International Council on Clean Transportation

April 23, 2013

http://bakercenter.utk.edu/wp-content/uploads/2013/06/Transition-to-Electric-Drive-2013-report.FINAL_.pdf

Thank you.